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27-28 February 1997: **Biodiversity at Risk: Patterns, Causes, Actions**

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Satellite Symposium

Giorgina Bernasconi¹ & Michael Krieger² (¹Universität Bern, Zoologisches Institut, CH-3032 Hinterkappelen, Schweiz; ²Université de Lausanne, IZEA, Bâtiment de Biologie, CH-1015 Lausanne, Suisse): Hierarchy of investment roles during cooperative colony founding as revealed by microsatellite DNA analysis in fire ants, *Solenopsis invicta*.

Cooperation among ant queens during colony founding considerably increases colony growth and survival. However, after fatal fights following worker eclosion only one queen monopolises the colony. Kin selection predicts that workers should bias the outcome of fights in favour of their mother or the most productive queen, while queens should restrain weight loss if this maintains their fighting ability. These two hypotheses make opposite predictions if brood production relates to weight loss. Using highly polymorphic microsatellite DNA loci we determined the genetic relationships of colony members at the time of queen execution in fire ants, *Solenopsis invicta*. The queen losing less weight in a pair and thus being most likely to survive did not have fewer progeny as expected. On the contrary, the higher the difference in weight loss, the more likely it was that the queen losing less weight had a higher share of the worker and larval brood. Differential weight loss is thus the expression of a stable hierarchy of roles between queens, with unequal partitioning of brood care tasks and differential cannibalism as potential mechanisms. These results thus reconcile the expectation that workers should favour the queen most likely to be their mother with the finding that differential weight loss is a predictor of queen survival.

Elmar F. Benelli & Paul Schmid-Hempel (Experimentelle Ökologie, ETH Zentrum NW, CH-8092 Zürich, Schweiz): Sources of variation in the immunocompetence of *Bombus lucorum*.

An immune system offers fitness advantages to individuals upon an attack of a parasite. But development and maintenance of immunity could itself have costs (energy, space, metabolites) and may therefore vary according to environmental conditions and coevolutionary history. We therefore predicted that alpine populations when compared to those from the lowlands are utilising a marginal habitat and generally face fewer parasites and thus would invest less into immunity. Furthermore, we expected that low temperatures would impose higher costs for the development and maintenance of immunity. We tested these predictions by exposing colonies of *B. lucorum* originating from two regions of Switzerland (lowland and Alps) to different temperature regimes (18°C and 28°C) and later implanting individuals of these colonies with an artificial parasitoid under standard conditions (20°C) to measure their encapsulation ability. Results only partially agreed with the predictions, notably alpine colonies were better defended. Possible effects of local adaptation and trade-offs with other functions will be discussed.

Max Reuter (Zoologisches Museum der Universität Zürich, Winterthurerstr. 190, CH-8057 Zürich, Schweiz): The pattern of female arrival at the mating site in the yellow dung fly *Scathophaga stercoraria* represents a mixed ESS.

Whereas male *S. stercoraria* colonise mating sites, freshly deposited dung pats, very rapidly females arrive at a low, decreasing rate over an interval of about five hours. In this study, it is hypothesised that the distribution of female arrival times represents a mixed ESS formed by different trade-offs between costs and benefits of early and late arrival. Early arrival is favoured as the substrate decreases in quality and is rapidly depleted; late arrival is favoured by diminishing negative effects of male-male competition on females. Computer simulations with arrival patterns deviating from the natural one were performed to "measure" the costs for females arriving at different times. These costs were compared with benefits calculated from

assumed functions, thus giving fitness estimates. This procedure revealed that in a population of females arriving shortly after deposition delayed females would be favoured. In a population arriving according to a uniform distribution early females would have a fitness advantage. Thus evolution would lead to an intermediate distribution of arrival times, as occurs in nature. Therefore it is suggested that the pattern of female arrival represents a mixed ESS and is adaptive. The simulation also revealed that the intensity of sexual selection by male-male competition is highest with the natural pattern of female arrival. Thus natural selection generating this pattern as a by-product amplifies the intensity of male-male interaction.

Heinz Richner, Anne Oppliger & Philippe Christe (Zoology Departments, Universities of Bern and Lausanne): Parasitism and the trade-off between current and future reproduction.

Evolutionary theory predicts a trade-off between current reproductive effort and future survival or fecundity. At the physiological level, this trade-off predicts that parents which invest heavily in their current offspring will have fewer resources to allocate to parasite defence, thereby impairing their own future reproduction. Evidence for this trade-off from two experiments on great tits will be presented (*PNAS*, 1995, Vol. 92, pp. 1192-1194; *Nature*, 1996, Vol. 381, p. 565) where reproductive effort was manipulated and the resulting susceptibility to malaria parasites assessed.

Claus Wedekind & Dora Strahm (Abteilung Verhaltensökologie, Zoologisches Institut, Universität Bern, CH-3032 Hinterkappelen, Schweiz): Strategic egg production in a hermaphroditic cestode.

The pseudophyllidean cestode *Schistocephalus solidus* is a simultaneous hermaphrodite that reproduces in the gut of birds. Reproduction can take place by self- or cross-fertilisation. These two modi of reproduction are expected to result in offspring of different viability. Moreover, reproduction by cross-fertilisation is expected to put hermaphrodites in a social dilemma situation (the "hermaphrodites' dilemma"). If this cestode species has the potential of a strategic egg production, we expect egg production to differ between *S. solidus* that reproduce alone or in pairs. In an *in vitro* system which we use to replace the bird, we observed that the egg production of the cestodes actually seemed to depend on their social situation. When kept alone, there was a strong correlation between worm size and egg size: larger cestodes produced larger eggs. There was no such correlation in cestodes kept in pairs, the difference between these two reproductive modi being highly significant in this respect. To control for some potentially confounding variables we did a series of experiments which verified these findings. The experiments furthermore revealed that these hermaphrodites produced more eggs and overall more egg mass when kept alone than when kept in pairs. This suggests that *S. solidus* is capable of adjusting its investment into its overall female reproductive output according to the situation it finds itself in the final host, i.e. whether it is alone or together with a potential mate. *S. solidus* also seems to be capable of adjusting its investment into each egg depending on its expected viability, i.e. whether the offspring is the result of self- or cross-fertilisation.

Betty Benrey (Center for Ecology, Universidad Nacional Autónoma de México, México and Institut de Zoologie, Université de Neuchâtel, CH-2007 Neuchâtel, Suisse): Host plant effects on the interaction between an insect herbivore and its larval parasitoid.

The species of host plant fed upon by a herbivore may affect its natural enemies directly or indirectly. I examined the influence of four host plant species (*Brassica oleracea*, *Tropaeolum majus*, *Lunaria annua* and *Cleome spinosa*) of the cabbage butterfly, *Pieris rapae*, on its interaction with the parasitoid *Cotesia glomerata*.

The indirect effects of plant species on *C. glomerata* were assessed by determining the relationship between development time of *P. rapae* and susceptibility to parasitoid attack across

the four plant species. Parasitism (%) was higher on larvae feeding on *B. oleracea* than on larvae on the other three host plants, and there was no clear relationship between development time of the host larvae and parasitism rates. The lack of association between larval growth rate and mortality across host plant species resulted from the direct effects of the host plant on the ability of *C. glomerata* to locate and attack their *Pieris* host.

Host plant species also indirectly influenced parasitoid performance by differentially altering the quality of *Pieris* larvae as a food resource for *C. glomerata*. Parasitoids developed more rapidly, produced larger clutches, survived better and emerged as larger adults when its host was feeding on *B. oleracea* and *T. majus*. Additionally, the sex ratio of *C. glomerata* emerging from larvae of *P. rapae* also differed across the four plant species.

The results from this study provide evidence that host plants mediate herbivore-enemy interactions by affecting the herbivore's vulnerability to parasitoid attack and the searching behaviour and performance of parasitoids.

Frédéric Tripet & Heinz Richner (Zoologisches Institut, Universität Bern, CH-3032 Hinterkappelen, Schweiz): Host responses to ectoparasites: food compensation by parent blue tits.

Parental food compensation has been proposed to account for the absence or small effects of parasites on offspring in various bird-parasite systems. An increase in the quantity of energy and nutrients provided by the adults would therefore compensate for the offspring's loss of blood to ectoparasites. We studied parental food compensation (*OIKOS*, *in press*) in a blue tit *Parus caeruleus* population with experimentally controlled infestations by the bird flea *Ceratophyllus gallinae*. Parental feeding effort, offspring quality, and parasite reproduction were measured in randomly assigned parasite-free and infested broods. Although the ectoparasites reproduced at a high rate in infested nests, the nestlings did not suffer higher mortality or reduced body size and body condition than nestlings in parasite-free nests. Parent blue tits of infested nests increased rate of food provisioning by 29%. The results support the parental food compensation hypothesis. No short-term costs (i.e. lowered body condition) of parasites on the parents could be detected. It suggests that parents alone bear the cost of parasitism. Life history models predict a trade-off between present and future reproduction, and evidence will be presented that the cost of food compensation is expressed by reduced survival of parents.

Kerstin Huck, Horst H. Schwarz & Paul Schmid-Hempel (ETH Zürich, Experimental Ecology, ETH Zentrum NW, CH-8092 Zürich, Schweiz): Phoretic mites discriminate between different castes of their bumble-bee hosts.

Mite species that utilise scattered microhabitats need specific dispersal strategies. All stages of the mite *Parasitellus fucorum* (Mesostigmata: Parasitidae) live in bumble-bee nests. For dispersal the deutonymphs (the last pre-adult stage) attach phoretically to adult bumblebees (*Bombus*: Hymenoptera: Apidae). Mites which are able to discriminate between bumblebee castes should have an advantage because only the queens overwinter. Deutonymphs of *P. fucorum* were found phoretic on both bumble-bee queens and workers in the field. However, they were detected significantly more frequently on the queens. In choice experiments carried out using a Y-tube, bumble-bee queens were more attractive to deutonymphs of *P. fucorum* than workers. In a further experiment, deutonymphs switched from males to queens but never from a queen to a male. Thus our behavioural results correspond with the caste-specificity found in the field.

Heinz-Ulrich Reyer, K. Bollmann, A. R. Schlöpfer, A. Schymainda & G. Klecack (Zoologisches Institut, Universität Zürich, Schweiz): Ecological determinants of extra-pair fertilisations and egg dumping in Alpine water pipits, *Anthus spinoletta*.

Behavioural ecology has successfully explained the diversity in social mating systems ("who lives with whom?") through differences in environmental conditions, but diversity in

genetic mating systems ("who mates with whom?") is poorly understood. The difference is important, where parents care for extra-pair young (EPY) originating from extra-pair paternity (EPP), extra-pair maternity (EPM) and intra-specific brood parasitism (IBP). In birds, IBP and EPM are rare, but EPP is widespread and highly variable among species and populations. Explanations for this variability are controversial, mainly because detailed ecological information is usually lacking in paternity studies. Here we present results of the first study to identify the ecological determinants of extra-pair activities for both sexes of the same species, the water pipit (*Anthus spinoletta*). DNA fingerprints of 1052 young from 258 nests revealed EPP in 5.2% of the young from 12.4% of the nests. EPM and IBP – both involving egg (EDP) – each occurred in 0.5% of the young from 1.9% of the nests. Nests with and without EPY could not be distinguished by traits of the breeders and by reproductive success, but they differed with respect to ecology: nests with EPP-young were characterised by asynchronous clutch initiation, nests with EPM- and IBP-young by higher overlap with neighbouring territories and closer proximity to communal feeding sites. We suggest that chance events, resulting from the temporal and spatial distribution of broods, offer a better explanation for the occurrence of extra-pair activities than female search for genetic or phenotypic benefits. This possibility of "accidental" extra-pair reproduction as an "ecological epiphenomenon" with low potential for selection should also be considered for species other than the water pipit.

Philipp Heeb, Isabelle Werner, Mathias Kölliker & Heinz Richner (Zoologisches Institut, Universität Bern, CH-3032 Hinterkappelen, Schweiz): Benefits of great tit responses against hen fleas.

Cavity-nesting birds often face ectoparasites inhabiting their nest and can show behavioural, physiological or immunological responses to them. Host responses have evolved as a way to reduce the impact that parasites have on their fitness. In our study, we investigated the responses of breeding great tits (*Parus major*) when infested by a common ectoparasite, the hen flea (*Ceratophyllus gallinae*). We also determined the fitness benefits arising from these responses. When infested by fleas, male but not female great tits increased their feeding rates. Such increase in feeding rates is thought to compensate for the negative effect of the fleas by increasing the amount of food delivered to the young. Females with infested nests increased the mass of the nests and tended to increase their nest sanitation behaviour. Male responses appeared to be based on flea assessments made early in the nesting cycle. Our results show that if flea infestations take place at the start of incubation, males did not increase their feeding rates and the birds produced young of lower body weights and sizes. In contrast, if flea infestations took place during egg laying, the responses of the great tits compensated for the effect of the fleas and no detectable flea virulence was observed. Thus, great tit responses reducing the effect of hen flea infestations can only be mounted if birds detect flea loads early in their nesting cycle.

Christian Som¹, Bradley R. Anholt² & Heinz-Ulrich Reyer¹ (¹Zoologisches Institut, Universität Zürich, Schweiz; ²Dept. of Biology, University of Victoria, Canada): The importance of female choice for the population structure of the *Rana esculenta* - *Rana lessonae* hybrid system.

Recent models of the structure and dynamics in mixed water frog populations indicate that exchange between ponds is essential for the coexistence of the hybrid *Rana esculenta* (E) and its sexual host *R. lessonae* (L). Our model predicts that female choice alone can lead to stable genotype frequencies in the L/E-system, even in isolated populations without migration between neighbouring ponds. Different mating frequencies of *R. esculenta* and *R. lessonae* females with *R. lessonae* males allow coexistence over a wide range of relative clutch size relations. If female choice is affected by the L/E-ratio of mating males, the genotype composition in the mixed populations develops faster to an equilibrium than if female choice is independent of the male ratio. Simulated disturbances of mixed populations with stable geno-

type frequencies showed that the model lacks global stability. Disturbance leads to L/E-equilibria different from those before the impact. Repeated disturbance can increase these differences which may explain why L/E ratios differ in nature. Populations with less than 10% of *R. lessonae* are very vulnerable and disturbance may cause a collapse of the mixed population.

Christina Chang Wai Ying¹, Michael J. B. Krieger¹, Kenneth G. Ross² & Laurent Keller¹ (¹Université de Lausanne, IZEA, BB, 1015 Lausanne, Suisse; ²University of Georgia, Dept. of Entomology, Athens 30602 GA, U.S.A.): Polygyny associated with high level of triploidy in the fire ant *Solenopsis invicta*.

Ploidy level of fire ant females was studied using microsatellites. More than 10% of the workers and queens were triploid in polygyne (multiple-queen colonies) populations. By contrast, not a single triploid individual was detected in monogyne (single-queen colonies) populations. This difference in ploidy level between the two social forms might stem from the presence of diploid males in the polygyne form. Males are generally haploid in Hymenoptera but a recent bottleneck resulted in a dramatic increase in the proportion of diploid males in the polygyne form only, with 83% of the males being diploid. These males were thought never to produce sperm. However dissection of diploid males showed that 2.4% of these males indeed produce sperm. These diploid fertile males may thus be at the origin of the high level of triploid females in the polygyne form.

Theo C. M. Bakker & Dominique Mazzi (Zoologisches Institut, Universität Bern, Schweiz); How necessary is paternal care for the development of stickleback embryos?

In species with exclusive male parental care, females may directly benefit by mating with males that occupy territories that are advantageous for embryo development and survival. One may thus expect male-male competition for territory quality and female mate choice for territory quality or male traits that indicate territory quality. We tested in the field (Roche near Montreux, Switzerland) whether variation in embryo survival was associated with physical variables at the nest, and whether successful males occupied better territories for embryo survival. We did this by depriving stickleback nests of paternal care during a variable period while preventing egg predation. The current velocity near the nest sites is relatively high in this population. In addition to the length of the deprivation period and the number of eggs, current velocity significantly correlated negatively with proportional embryo mortality. Males with intense blue eye had a high relative reproductive success and were occupying the best territories for embryo survival.

Else J. Fjerdingstad¹ & J. J. Boomsma (Dept. Ecology & Genetics, Aarhus University, Ny Munkegade 540, DK-8000 Aarhus C, Denmark. ¹ After Feb. 1st, 1997 at: Institut de Zoologie et d'écologie animale IZEA, Bâtiment de Biologie, Université de Lausanne, CH-1015 Lausanne): Polyandry and multiple paternity in the Leafcutter ant *Atta colombica* - Do queens mate multiply for more sperm?

Polyandry (multiple mating) by ant queens is considered an evolutionary puzzle: it is likely to be costly for queens and clear benefits have not yet been demonstrated. Hamilton (1964) and Cole (1983) suggested that queens of large colony species may have to be polyandrous in order to obtain large sperm stores. In this study we tested an individual-level version of this hypothesis in the Panamanian leafcutter ant *Atta colombica*, a highly polyandrous large colony species. We found that the number of sperm stored by queens correlated positively with their mating frequency as estimated through microsatellite DNA mother-offspring analysis. Also, we show that storing more sperm is likely to enhance the potential

fitness of a queen. This is the first evidence genuinely in favour of the "mating-multiply-for-more-sperm" hypothesis. It is also the first evidence that polyandry in ants may be selectively favoured for causes not related to genetic diversity or relatedness effects of multiple paternity.

Mathias Kölliker, Heinz Richner, Isabelle Werner & Philipp Heeb (Ethologische Station Hasli, Zoologisches Institut der Universität Bern, Schweiz): Begging signals and biparental care: nestling great tits discriminate between parents.

In birds, biparental care is the norm and evidence that male and female parents differ concerning their simultaneous investment pattern in individual offspring is growing. How and why do such interparental differences arise, given that both parents depend on nestling signals for appropriate food allocation? In this study, we report an experiment carried out on great tits (*Parus major*) where nestling hunger level was manipulated by food deprivation and hand-feeding. Subsequent filming revealed that parents made themselves recognisable by feeding from different and stable locations within the nest. Nestlings approached the female but not the male if previously "food-deprived", retreated (or were displaced by siblings) from positions near the female but not the male it artificially "fed". Females allocated a 58% higher proportion of feedings to hungry nestlings than males. Recognisability may allow parents to favour different nestling phenotypes (e.g. need, sex, size) in close positions and hence for feeding. Individual parents may likewise be able to adjust nestling begging signals to their own optimal (short-term) investment pattern.

Steven N. Fry & R. Wehner (Zoologisches Institut, Universität Zürich, Schweiz): How honey bees use a single landmark to locate a food source.

Honey bee foragers repeatedly visit a rewarding food source. Amongst other navigational strategies, landmarks along the route and near the feeding site are used for visual guidance. What landmark information do the bees store, and how are memora and present visual input used to guide the bee to a certain location?

Bees were trained to enter a uniform flight arena (diameter 2.4 m) and fly to a small hole devoid of olfactory cues at 1.9 metres distance. The bees then passed through the hole to receive a food reward, after which they left the reward box directly. A single black cylindrical landmark was placed 50 cm to the side of the hole. Successive flights of experienced bees were video-recorded and digitised for analysis.

The bees never flew in a straight line to the hole, but chose an initial heading towards the cylinder, which they then passed, swerving directly towards the hole.

Analysis of the azimuth of the landmark, as it appeared to the bees, show that they approached the landmark keeping it in a near frontal position, within about 60° of the visual field. Similarly, bees trained to a frontal landmark fixated it within about 60° of the frontal retina.

A bee flying a straight course perceives objects in motion, unless the object is located directly in front of it. We have shown that bees avoid inducing image motion, by first aiming for the landmark. Paradoxically, the bee avoids the bee-line to the goal.

Main Symposium

Invited lectures

Robert D. Holt (The University of Kansas, Natural History Museum, Lawrence, KS 66045-2454 U.S.A.): The conservation implications of niche conservatism and evolution: a theoretical perspective.

Many species world-wide are at risk of extinction because of a wide range of human activities, including habitat destruction, direct mortality pressure, the introduction of exotics,

and management practices (e.g., pesticide application). Given that most natural populations harbour genetic variation for many characters, evolutionary processes can in principle modulate extinction risk. Yet a general theme of the history of life is that species exposed to novel environments often fail to adapt. In my lecture, I first sketch some examples of such “niche conservatism”. I then present a conceptual framework which emphasises how population dynamics can constrain evolutionary responses. Although the overall message is rather sobering, the framework does highlight features of landscape structure which facilitate rapid evolution to novel environments, potentially rescuing populations from extinction. Finally, these insights are applied to an important applied ecological problem – the long-term evolutionary stability of biological, versus chemical, control of pest organisms.

Paul M. Brakefield (Institute of Evolutionary and Ecol. Sciences (EEW), Leiden University, The Netherlands): Genetics and habitat fragmentation: some empirical data from studies of butterflies.

The general features of potential genetic problems in small natural populations are illustrated with particular attention to butterflies. I will then show how laboratory experiments using a tropical butterfly are detecting the potential roles of genetic drift, inbreeding and gene flow.

Robert D. Martin & Franziska von Segesser (Anthropologisches Institut, Universität Zürich, Schweiz): The Barbary macaque as a model for conservation biology of primates.

Endangered species face a set of common problems, notably drastic reduction in total habitat area combined with habitat fragmentation. Because of overall reduction in population size and isolation of subpopulations, loss of genetic variation is assumed to be a major factor threatening the survival of isolated relict populations, but empirical data are still relatively scarce. Among primates – long-lived mammals with complex social patterns – the Barbary macaque (*Macaca sylvanus*) is an instructive model for studying genetic effects of population decline. Surviving wild populations in Algeria and Morocco are severely fragmented and genetic isolation is also of central concern for the management of existing captive populations. Fundamental questions that need attention include assessment of the genetic effects of isolation, definition of minimum viable population size and determination of the requisite level of gene flow between subpopulations.

The Barbary macaque is a particularly suitable test case because it has been possible to sample the entire wild and captive world population through an international collaborative network. The overall population is subdivided into subpopulations of different sizes and degrees of isolation. An ongoing project is applying DNA-typing methods to assess genetic variability in wild and captive Barbary macaques. Pilot studies using protein electrophoresis and multilocus DNA fingerprinting showed that Barbary macaques have low genetic variability in comparison to other macaque species, so work on microsatellites was initiated. Over 300 blood samples have been collected from four wild populations in Algeria, two semifree-ranging subpopulations in Europe of Moroccan origin, one mixed zoo colony and an extremely isolated colony of uncertain origin on Gibraltar.

For our studies using PCR-based microsatellite analysis, emphasis was placed on developing non-invasive sampling techniques (e.g. using DNA extracted from hair-root cells) and on the use of non-radioactive labelling techniques. We present results for six hypervariable microsatellite loci (primers supplied by M. Inoue and M. Bruford). The microsatellite markers used are highly variable (average heterozygosity about 55% within each subpopulation) and permit identification of pronounced differences in both distribution and degree of variation between subpopulations. There is, for instance, a clear distinction between Algerian from Moroccan macaques. Results from the small isolated colony in Gibraltar are particularly interesting with respect to potential effects of long-term inbreeding.

Helmut Zwölfer (Universität Bayreuth, D-95440 Bayreuth, Germany): Evolution of the diversity of plant-insect communities: the example of the fauna of Cardueae host plants.

Plant-insect communities, i.e. groups of organisms co-occurring in the same area, connected by trophic links and interacting through antagonistic and synergistic relationships form an essential element of the biodiversity of terrestrial ecosystems. Thus, a study of the evolution of plant-insect foodwebs offers a chance to gain insight into processes involved in the evolution of biodiversity. This will be shown for the insect fauna of the Cardueae (= thistles in the broad sense). In this host group a comparative analysis of food webs and guilds is possible over much of its Holarctic distribution range. Together with data on phylogenies, fossil records, biogeography, host race formation and functional morphology it allows to reconstruct steps and to identify driving forces in the evolution of the faunal diversity associated with a major plant taxon. The study shows that the four stages postulated by K. O. Wilson (1969) for the development of communities are well represented in the Cardueae fauna, the evolution of which can be traced back to the late Oligocene and Miocene. Starting from random assemblies of the "non-interactive phase", levels of guild organisation and complexity of life-histories increase over an "interactive phase" and an "assortative phase" and reach a maximum in the final "evolutionary stage".

Peter K. Endress (Institut für Systematische Botanik, Universität Zürich, Schweiz): Unknown diversity.

Like complexity, diversity of life has many dimensions. Two prominent aspects are (1) the diversity of clades, which are in the focus systematics / phylogenetics, and (2) the diversity of landscapes, which are in the focus of ecology. The first aspect deals with all constituents of a phylogenetically defined (monophyletic) group and their relationships at a worldwide scale, the second with all organismal constituents of a geographically restricted region and their interrelations. I will focus on the first aspect and on plants. The last five years have seen an unprecedented progress in systematic botany due to new techniques, especially molecular systematics. At the same time gaps in our knowledge of the diversity of even spectacular and "familiar" plants become more obvious. This will be illustrated. In addition, the basal diversity of angiosperms, the most diverse plant group, will be highlighted, which is of special importance also for large scale conservation issues.

David M. Newbery (Vegetation Ecology Group, Geobotanisches Institut, Universität Bern, CH-3013 Bern, Schweiz): Bernoulli and the botanist: sampling problems in the tropics.

Very species-rich rain forest vegetation presents major problems for sampling and understanding the processes which determine its structure, composition and dynamics. How probable is it, for example, that a tree of one species will be a neighbour to that of another? Either we submit to the "laws of chance" or we have to adopt a new approach.

Actions for perception and maintenance of biodiversity

Andreas Gigon¹, Regula Langenauer¹, Claude Meier² & Bernhard Nievergelt² (¹Geobotanisches Institut, ETH Zürich; ²Zoologisches Institut, Universität, Zürich, Schweiz): Blue Lists – a new encouraging instrument in nature conservation.

The Red Lists become longer and longer indicating that biodiversity is decreasing. This often leads to a negative and discouraging picture of nature conservation. But is this whole story? As a new instrument for monitoring the success of nature conservation the Blue Lists were developed: registers of those Red List species that show a stabilisation or increase of

abundance in the area investigated. These changes can be due to the application of nature conservation, but also to factors like climatic change or eutrophication.

The instrument of the Blue Lists comprises six categories concerning the change of abundance of the individual species in the area investigated. As an addition to the Blue Lists, six other categories assessing the effect of the application of nature conservation techniques on the individual species are defined. Nature conservation techniques are conservation measures that have a direct effect upon species.

Weaknesses, strengths and possibilities for the application of the Blue Lists in nature conservation are discussed.

Andreas Gigon¹, Regula Langenauer¹ & Claude Meier² (¹Geobotanisches Institut, ETH Zürich; ²Zoologisches Institut, Universität, Zürich, Schweiz): Blue Lists of animal and plant species of the Red Lists in northern Switzerland.

The Blue Lists (registers of those Red List species that show a stabilisation or increase of abundance in the area investigated) are presented for the vertebrates, butterflies, grasshoppers and dragonflies of the cantons of Aargau, Schaffhausen and Zürich.

Of the over 200 animal and 700 plant species assessed – all in the Red List categories “vulnerable” or “threatened” – approximately 30% experienced a stabilisation or increase of abundance in the investigation area in the last 10-15 years. About 20% of the species show a decrease in abundance; for the remaining 50% the development of the abundance during the last 10-15 years is not known but it is probably mostly declining.

For about 80% of the investigated Red List species nature conservation techniques, which can lead to a stabilisation or increase of abundance, have been successfully applied or are at least known. A wider application of these techniques could lead to a stabilisation or even increase of the abundance of a large number of Red List species.

Thus, nature conservation also shows successes, which could even be enlarged considerably. The positive picture given by the Blue Lists can hopefully help to increase the motivation for the conservation of Nature.

Martina Gebhardt (Sozialökonomisches Seminar der Universität Zürich, Schweiz): Ökonomische Aspekte der Erhaltung der Biodiversität.

Die Erhaltung des Regenwaldes, als Ort der grössten biologischen Vielfalt, ist trotz international anerkannter Bedeutung nicht sichergestellt. Die konkurrenzierende Nutzung des Regenwaldes (Tropenholzexport, Transformation in Weideland, etc.) führt zu einer Zerstörung des Regenwaldes und somit der Biodiversität. Die Biodiversität muss eine finanzielle Wertsteigerung erfahren, um konkurrenzfähig gegenüber den anderen Gütern zu werden. Eine Möglichkeit der monetären Bewertung der Biodiversität kann über die Erfassung des Nutzens für die Pharmaindustrie dargestellt werden. Die Biodiversität gilt als potentielle Basis für neue Medikamente. Das Interesse der Pharmaindustrie an der Biodiversität manifestiert sich zum Beispiel im Vertrag zwischen Merck, USA und INBio, Costa Rica. Dabei stellt Costa Rica “ihre” Biodiversität dem Pharmaunternehmen zu Forschungszwecken zur Verfügung. Als Gegenleistung ist Costa Rica an den daraus resultierenden Medikamenten umsatzbeteiligt (Royalties). Dieser Vertrag ist der erste, der den “Besitzern” der Biodiversität, als Anbieter ihrer Ressource, eine Abgeltung gewährleistet. Die Royalties können dabei als Preis für das Nutzungsrecht des Pharmaunternehmens gesehen werden. Dadurch erhält die Biodiversität eine finanzielle Wertsteigerung. Ein wesentliches Problem bei der Ausgestaltung eines solchen Vertrages ist die Bewertung der Biodiversität. Das Pharmaunternehmen kennt den Wert der konkurrenzierenden Güter, der Marktwert der Biodiversität ist hingegen nicht bekannt. Im Vertrag wird daher ein Wert vereinbart, der nur leicht über dem Wert der konkurrenzierenden Gütern liegt und den effektiven Wert der Biodiversität nur ungenügend widerspiegelt. Eine alternative Methode zur Berechnung des monetären Nutzen der Biodiversität ist die Ertragswertanalyse. Die zukünftigen Erträge der Nutzung durch die Pharmaindustrie werden auf heute abdiskontiert und mit dem gegenwärtigen Ertrag der konkurrenzierenden Nutzung verglichen.

Susette Biber-Klemm (Institut für Rechtswissenschaften, Universität Basel, Schweiz): Erhaltung der Lebensräume – Instrumente und Strategien des Rechts.

Ausgehend von der Konferenz der Vereinten Nationen über die Umwelt von 1972 (Stodkholmer Konferenz) hat sich der Grundsatz des "sustainable use" – in Rio erweitert zur "nachhaltigen Entwicklung" – auch in der Rechtsordnung zum Schutz und zur Erhaltung der natürlichen Lebensräume niedergeschlagen.

Die vom Recht zur Verfügung gestellten Instrumente und deren Umsetzung entwickelten sich von lokalen und punktuellen Schutzmassnahmen zur grossflächigen Prävention und Integration. Dieser Prozess wurde durch internationale Entwicklungen insbesondere im Bereich der Landwirtschaft unterstützt. Der Schutz von Ökosystemen und Lebensräumen von Arten ist allerdings seit jeher schwierig – zu viele verschiedene Interessen konzentrieren sich auf das knappe Gut Boden.

Von verwaltungs (rechtlicher) Seite her ist der Vollzug des Umweltrechts im allgemeinen und somit auch des Naturschutzrechts aktuell geprägt durch Entwicklungen, die Deregulierung, Übernahme von Eigenverantwortung, Freiwilligkeit der Umsetzung durch Setzung von wirtschaftlichen Anreizen postulieren.

In diesem Umfeld findet die Umsetzung der rechtlichen Vorgaben zum Schutz und zur Erhaltung der natürlichen Lebensräume von Tieren und Pflanzen statt.

Ihr Erfolg ist nicht nur geprägt von den gesetzlichen Vorgaben. Positionen und Funktionen der beteiligten Akteure, Wahl und Einsatz der Instrumente, organisatorische, finanzielle und personelle Faktoren beeinflussen die Wirksamkeit. Nicht zuletzt spielt auch Information und die Art und Weise des wissenschaftlichen Inputs eine Rolle. Gefragt wären praxisnahe Fragestellungen und Kommunikation zwischen Theorie und Praxis.

Patterns of and causes for the decline of biodiversity in Europe

Anna-Katherina Holenweg & Heinz-Ulrich Reyer (Zoologisches Institut, Universität Zürich, Schweiz): Migration and population dynamics in a water frog metapopulation.

The structure and dynamics of mixed water frog populations, consisting of individually marked *Rana lessonae*, *R. ridibunda* and their hybridogenetic associate *R. esculenta*, were studied at nine neighbouring breeding sites in Switzerland. We found all three genotypes in all ponds, but their relative numbers were significantly related to pond size and shape. Pond-specific composition persisted even when relative genotype frequencies in the whole population changed between successive years. Although most of the frogs remained at the same pond during summer and returned to the same pond after hibernation, there was considerable exchange of reproductive water frogs between eight of the nine neighbouring sites. 3% of all marked frogs ($n=2735$) and 10% of those recaptured ($n=932$) changed ponds within seasons (1995 and 1996), 2% and 12%, respectively, did so between seasons. Thus, with the exception of one pond isolated by a highway, neighbouring ponds must be considered as parts of a metapopulation rather than as separate populations. These findings are consistent with recent models indicating that composition and stability of communities strongly depends on the movements of organisms between neighbouring resource patches, in our case breeding sites.

Sylvie Barbalat (Institut de Zoologie, Emile Argand 11, 2007 Neuchâtel): Forest structures and wood beetle diversity: the example of the Buprestidae, Cerambycidae, phytophagous Scarabaeidae and Lucanidae in the Areuse Gorges (NE).

The species diversity of selected wood beetles (Buprestidae, Cerambycidae, phytophagous Scarabaeidae and Lucanidae) between various forest stands showing different ecotone structures has been compared. Window traps and coloured plates have been used. Among the 65 captured species, 13 belonged to the Buprestidae, 41 to the Cerambycidae, 8 to the phyto-

phagous Scarabaeidae and 3 to the Lucanidae. Forest stand and clearing type have been found to have a significant influence on these beetle communities. In oak stands we find several typical oak species, while in beech stands only one characteristic species has been found. Phytophagous Scarabaeidae, which live in half-open habitats are typical edge species. Natural edges are characterized more precisely by Cerambycidae and Buprestidae living in herbaceous plants and shrubs. In artificial clearings, Cerambycidae and Buprestidae living in stumps or in branches left after a cutting have been found to be characteristic. Diversity indices have been calculated. Although no significant difference between diversity indices in artificial clearings or in edges has been found, the species are not the same in these two types of biotopes. Therefore, both are to be conserved in order to maintain a maximal biodiversity in forest.

Christoph Jäggi & Bruno Baur (Institut für Natur-, Landschafts- und Umweltschutz (NLU), Universität Basel, St. Johans-Vorstadt 10, CH-4056 Basel, Schweiz): Overgrowing forests threaten local populations of the “Juraviper” (*Vipera aspis*).

Habitat alterations can lead to species extinction. In the northwestern Swiss Jura mountains, the Asp viper *Vipera aspis* was common until the 1940ies. During the past 50 years many populations went extinct and today the species is threatened. We examined habitat characteristics at localities with extant viper populations and at localities where the species went extinct in the past 50 years. Localities with extant populations did not differ in altitude, inclination, soil structure and cover of ground vegetation. Localities where the species persisted are situated more frequently at the forest edge, in dry meadows and at roadsides, whereas localities in which *V. aspis* went extinct are situated more frequently in forests. Furthermore, the density of woody plants is lower at localities where the viper still occurs. The results show that the former habitats of *V. aspis* became overgrown by bushes and trees, which in turn may have led to a colder and more humid microclimate. These alterations of the habitats may cause the local extinction of this viviparous snake. We conclude that logging is an essential tool to maintain the habitat suitability for this thermophilous reptile.

Samuel Zschokke¹ & Peter Studer² (¹Institut für Natur-, Landschafts- und Umweltschutz (NLU), Universität Basel; ²Zoologischer Garten, Basel, Schweiz): Preservation of genetic diversity in the captive population of the Great Indian Rhinoceros.

Great Indian Rhinoceros (*Rhinoceros unicornis*) – one of the most endangered large mammals – have been kept in captivity for more than 50 years now and are distributed in zoological gardens world-wide. Breeding in captivity was first successful at Basel Zoo in 1956. Nowadays, 82 of the 130 Indian Rhinoceros kept in zoos are zoo-born. Until recently, however, little attention was paid to the genetic health of the zoo-population.

In the present study we analysed, based on the studbook, the breeding history and its genetic consequence on the zoo population of the Indian Rhinoceros. Inbreeding coefficients of zoo-kept Indian Rhinoceros vary between 0% and 37.5%. At present, nearly 50% of the genes of all zoo-born Indian Rhinoceros stem from three founder individuals, whereas the other 29 founders contributed the other half of the genes. The founder equivalent, a measure to describe the genetic health of a zoo population, is 10.16. For a viable zoo population, a founder equivalent of at least 20 is considered to be necessary.

We analysed the outcome of seven more or less hypothetical breeding programmes for Basel Zoo and their impact onto the genetic health of the world-wide zoo population.

Irene Bisang (Dept. of Botany, Stockholm University, S-106 91 Stockholm, Sweden. Formerly: Institut für Systematische Botanik, Zollikerstr. 107, CH-8008 Zürich, Schweiz): Endangered bryophytes – Swiss and European perspective.

The “Red Data List for Swiss Bryophytes” indicates that 39% of the 1030 bryophyte species known to occur in Switzerland have vanished (5) or are rare and/or threatened

(214/182). Drainage of wetlands, intensified agriculture and forest management, and atmospheric pollution are found as the main causes of threat to species and populations. A **bryophyte species conservation plan** was elaborated on behalf of the Swiss National Office for Environment, Forest and Landscape (BUWAL). It is based on the examination of 525 individual records of taxa in acute need of protection. Only 31% of about 200 formerly known populations could be refound in a field survey, the proportion of confirmed populations being smallest in the Plateau (Mittelland). The report is addressed to the nature conservancy authorities of the 26 Swiss cantons and describes broad outlines for species conservation programmes. A separate **documentation** provides data sheets for the confirmed and recently discovered populations of the selected taxa with recommendations for practical conservation measures. Data on the population biology of *Anthoceros agrestis* and *Phaeoceros carolinianus* (hornworts; Anthocerotatae) and the implication for conservation actions are presented as an example. – National Red Data Lists for bryophytes have been compiled in 18 European countries, but bryophytes were rarely included in practical conservation efforts so far. Moreover, there is a strong need for rational assessments of conservation priorities on a larger scale to use the limited available resources in an optimal way. The recently published "Red Data Book of European Bryophytes", judging one fourth of the bryoflora as threatened or rare on the European level, is an important step in this direction.

Felix Gugerli¹, Martin Bauert², Ingrid von Flüe¹, Rolf Holderegger¹, Eva Lutz¹ & Jakob Schneller¹ (¹Institut für Systematische Botanik, Universität Zürich, Zollikerstr. 107, 8008 Zürich; ²Geobotanisches Institut, ETH Zürich, Zürichbergstr. 38, CH-8044 Zürich, Schweiz): Patterns of genetic variation in populations of five different *Saxifraga* species with respect to distribution, habitat and reproduction.

Species of *Saxifraga* are important elements of the circumarctic and alpine flora. There is large variation in the genus with regard to ecological and evolutionary parameters, such as geographic distribution, habitat characteristics, population history, life-form, breeding system, and potential for asexual reproduction. We studied five species (*S. aizoides*, *S. biflora*, *S. cernua*, *S. mutata*, *S. oppositifolia*), which represent a wide array of the above mentioned variation within the genus. To investigate the genetic variation within and among populations, we used isozyme electrophoresis or RAPDs. The investigations covered different geographical scales and biogeographical situations, e.g., isolated relic populations of the arctic-alpine *S. cernua* or high alpine populations of *S. oppositifolia* from its continuous main distribution area in Central Europe. The reproductive strategies partially explained the detected patterns of genetic variation of the respective species. But only when several additional parameters are taken into account, i.e., biogeography, habitat dynamics, population size, or flowering phenology, can we relate our results to expectations which are based on theoretical concepts.

Ruth Streitwolf-Engel, Marcel G. A. van der Heijden, Ian R. Sanders, Thomas Boller & Andres Wiemken (Botanisches Institut, Universität Basel, Hebelstr. 1, CH-4056 Basel, Schweiz): Sexual and asexual reproductive traits of two *Prunella* species are influenced by co-occurring arbuscular mycorrhizal fungi.

P. vulgaris and *P. grandiflora*, like most perennials of species-rich grasslands, have the possibility to reproduce both sexually and asexually. The population structure of these two species will be affected by the proportion and frequency of sexual propagation versus clonal propagation. In both species, clonal reproduction is dependent on stolon branching intensity and stolon length. Differences in these traits are normally explained either as genotypic effects or as effects of environmental heterogeneity. We investigated the influence of colonisation by different arbuscular mycorrhizal fungi (AMF), which were isolated from a species-rich calcareous grassland, on reproductive traits of *Prunella*. The different AMF isolates had significantly different effects on clonal growth in each of the two plant species. AMF differentially influenced the stolon branching intensity and stolon length in *P. vulgaris* and flowering in *P.*

grandiflora. Although our experiment included mixed genotypes of *Prunella*, the AMF isolate effect was very strong, suggesting that it plays an important role. To test this, several genotypes of *P. vulgaris* were collected from the field site, propagated by meristem culture and grown with several AMF isolates from the same field site. First results show that there is a significant effect of plant genotype on clonal growth as well as an AMF isolate effect. Our results suggest that AMF have the potential to affect the number and distribution of ramets in *Prunella* populations as well as their genetic diversity. The genotypic variation is shown to be important in affecting clonal growth, but the AMF occupying the roots is just as important as a potential regulator of plant populations.

Nicolas Maire¹, Daniel Borcard², Willy Matthey² & Endre Laczko³ (¹C/Reloj 1, E-13300 Valdepeñas (C. Real), Spain; ²Institut de Zoologie, Université de Neuchâtel, Emile-Argand 11, CH-2007 Neuchâtel, Suisse; ³SOLVIT, Langsägestrasse 15, CH-6010 Kriens, Schweiz): Organic matter recycling in grassland soils of the Swiss Jura mountains: biodiversity and strategies of the living communities.

Several characteristics of the soils of three nutrient-poor grasslands, pertaining to the biological activity in the soils, have been measured three times during the vegetative cycle of 1994 in the Swiss Jura: abundances of the faunal groups Collembola (Insecta), Oribatida, Gamasida and Actinedida (Acarina), PLFA spectrum (Indicating microbial diversity), ATP content (an index of soil biomass) and soil respiration (CO₂), as well as the enzymes alkaline phosphatase, urease, chitinase, xylanase and laminarinase, as biochemical tracers of biotic activity.

Most of these variables show significant differences from site to site. In particular, the biochemical descriptors ATP, phosphatase and urease vary in accordance to the importance of the argilo-humic complex.

Seasonal variations are also important, and conditioned by organic matter recycling. The studied soils show **two strategies of litter degradation**: (a) an **enzymatic strategy**, prevailing at the end of winter, when the edaphic climate is unfavourable; (b) a **biotic strategy**, based upon the work of the whole living community (fauna and microflora), at its maximum at the end of summer and in autumn.

Diversity of the microbial communities (as estimated by the PLFA diversity) is highest in spring, when the carbon sources are complex (young litter), and decreases along the season, in inverse relationship with the specific activity of the biomass (CO₂/ATP ratio). This behaviour is attributed to an increase of the amount of simple organic compounds. This increase is probably due both to the enzymatic activity and to the activity of microphytophagous microarthropods.

Monitoring: methods, scales and priorities

Urs Hintermann (Hintermann & Weber AG, CH-4153 Reinach): Monitoring of biodiversity in Switzerland.

The changes of biodiversity (genetic diversity, species diversity and diversity of habitats) in Switzerland are to be surveyed in a long-term project, the Biodiversity Monitoring of Switzerland (BDM-CH).

At the present time BDM-CH includes 30 indicators. Indicators concerning the state of species diversity are inevitably central. Most of the indicators can be calculated from already existing data. A few central indicators require additional data-gathering programmes: the frequency of common species and the species richness in cultivated and other areas are to be surveyed by systematic sampling.

Annual reports based on series of data stretching over a period of five to ten years are planned. Statements concerning the whole of Switzerland are most important. At the same time statements can be made referring to areas covering at least 10% of the country's surface.

Reports on biodiversity are aimed at many different groups (i.e. administration, politics, general public, NGO) with very varying requirements. The information must therefore be individually prepared for each of these groups.

Philippe Jeanneret (Eidg. Forschungsanstalt für Agrarökologie und Landbau (FAL), Reckenholzstr. 191, 8046 Zürich, Schweiz: Biodiversity (species diversity) analysis): on the need of defining the purpose and using a multimethod approach.

While studying the biodiversity, the analysis of data based on species lists is a crucial point. Usually, people use some synthetic value like the well known Shannon and Simpson index to describe the species diversity. Another method is to relate the individual distribution within the species to models like the logarithmic series model. These methods are proved to be relevant in appreciating the structure of a given community and can also be used to compare sites or ecosystems and relate the biodiversity to environmental factors through the simple and multiple regression analysis. The advantage of using an index is that a lot of information is summarised in only one value. The disadvantage is that we lose information about the species themselves. Indeed, when sites are compared with an index, it is realistic to have values very close to each other if not equal, but the community can be composed with a completely different set of species with a very different ecological meaning. It is then particularly difficult to interpret the relationship between the investigated community and the environmental variables that could explain the difference between sites. It is therefore necessary to use a multidimensional approach, using multivariate analysis and associated statistics (Principal Component, Canonical. Corresp. Analysis, etc.). These methods are particularly adapted to the comparison of sites and to the investigation of the relationship between the studied community and the environment. It has the advantage to keep the information about the species, because the methods compare the sites not only on the basis of the individual distribution within the species, but also taking into account the species list for each site. Furthermore, to relate the community to the environmental variables, it is possible to use the variance partitioning like in the regression analysis.

Christoph Scheidegger, Stefan Zoller & B. Frey (Institut für Wald, Schnee und Landschaft (WSL), CH-8903 Birmensdorf, Schweiz): Strategies for the conservation of epiphytic lichen populations.

Intensified agricultural or forestry management, acidic air pollution and/or ozone are major causes for the decline or local extinction of numerous epiphytic lichen species. Populations of rare epiphytic lichens are often restricted to a very low number of trees and the main threat for the lichen is the death or cut-off of its substrate. Although habitat conservation such as the protection of phorophytes or the specific management measures of the forest stand is essential for the maintenance of small populations, specific conservation measures at the population level are needed in order to reduce the influence of environmental stochasticity. Long-term maintenance of the population could probably most successfully be realised by increasing the population size in terms of number of trees colonised by the lichen species.

Transplantation of vegetative diaspores of various threatened lichens such as *Sticta sylvatica*, *Lobaria pulmonaria*, *Bunodophoron melanocarpus* and *Parmotrema crinitum* enabled the establishment of additional populations. Because harvesting vegetative diaspores did not negatively influence the natural population, this method was found to be a suitable approach for lichen conservation activities aimed at increasing small and therefore endangered populations.

Niklaus Zbinden (Schweizerische Vogelwarte Sempach): Die Überwachung der Avifauna in der Schweiz. Methoden – Stand – Bedeutung.

Die Überwachung von Fauna und Flora ist insbesondere für die Festlegung von Prioritäten im Naturschutz und den Vollzug verschiedener gesetzlicher Bestimmungen wichtig. Dank einer grossen Zahl von Amateurspezialisten ist die Voraussetzung für Datenerhebung bei den Vögeln besonders günstig. Da Artenzusammensetzung und Bestandsgrösse sich ständig wandeln, ist eine kontinuierlich Überwachung nötig. Die Schweizerische Vogelwarte Sempach sammelt seit den 1950er Jahren Beobachtungsmeldungen, und das Meldewesen wurde anfangs der 80er Jahre stärker standardisiert. Neben den Zufallsmeldungen wird von Amateuren auf

alljährlich bearbeiteten Flächen die Bestandsentwicklung der eher häufigen Arten erhoben. Da die ehrenamtlichen Mitarbeiter und Mitarbeiterinnen in erster Linie im Mittelland aktiv sind, erhalten wir für diesen wichtigen, vom Menschen stark geprägten Raum aussagekräftige Daten, während aus den Alpen und aus dem Jura wesentlich weniger Beobachtungen gemeldet werden. Um ein repräsentatives Bild der Situation der Avifauna der Schweiz zu erhalten, wird gegenwärtig ein Überwachungsprogramm entwickelt, bei dem vorgegebene Flächen zu bearbeiten waren. Für deren Auswahl ist neben einer ausgewogenen geographischen Verteilung die praktische Durchführbarkeit zu berücksichtigen, insbesondere im schlecht zugänglichen Alpenraum. Neben der Bestandsentwicklung ist die Erfassung der Verbreitung und deren Veränderung ein wichtiges Kriterium für die Beurteilung der Situation einer Vogelart. Dazu werden Atlasprojekte durchgeführt. Eine erste Aufnahme erfolgte 1972-76, die zweite 1993-96. Die Überwachung ist von besonderer Bedeutung, wenn gezielt Landschaftsaufwertungen vorgenommen werden und eine Erfolgskontrolle durchgeführt werden soll.

Biodiversity in grasslands

Bernhard Schmid, Jasmin Joshi & Matthias Diemer (Institut für Umweltwissenschaften, Universität Zürich, Winterthurerstr. 190, CH-8057 Zürich, Schweiz): Biodiversity and the restoration of permanent grassland.

With large areas of land taken out of the agricultural system in Europe it becomes an important question how the abandoned land should best be restored. With respect to ecosystem and landscape integrity the best option may often be to establish permanent grassland that is managed by low-intensity mowing or grazing. In a European-wide programme experimental plots with 1, 2, 4, 8, and >10 plant species were set up at eight locations, including one in the Jura mountains near Basel (village of Lupsingen). The first two years of observations and measurements show that both ecosystem properties as well as population dynamics of selected species are strongly influenced by plant diversity. Often, these response variables are linearly related to the logarithm of plant species number, suggesting that the omission of a fixed proportion of species in a sown grassland (or the loss of species in a natural grassland) is more problematic in low- than in high-diversity systems. The preliminary conclusion of our research is that permanent grassland can faster be restored if high- rather than low-diversity mixtures are sown (faster build-up of vegetation cover and standing biomass, greater invasion resistance, etc.). The further monitoring of the experiment will show if these effects also translate into long-term differences among the mixtures.

Paul W. Leadley, Pascal Niklaus, Reto Stocker & Christian Körner (Botanisches Institut, Schönbeinstrasse 6, Universität Basel, CH-4056 Basel, Schweiz): Effects of experimental manipulations of plant diversity on ecosystem function in a calcareous grassland.

In order to determine the effects of a decline in species richness on ecosystem function in calcareous grasslands, we manipulated plant species number and CO₂ concentrations at a low altitude field site in the Jura Mountains of Switzerland. Experimental plots were planted with 5, 12 or 31 species of plants commonly found in the calcareous grasslands of the region and then these plots were exposed to ambient or elevated CO₂. Three years after planting we find that decreasing species number led to a reduction in aboveground plant biomass, particularly in the fall, and reductions in plant biomass were accompanied by lower rates of canopy photosynthesis. We also observed that soil solution concentrations of nitrate increased with declining diversity, but we saw no change in soil water content. The primary effect of elevated CO₂ at all diversity levels was to increase canopy photosynthesis and soil water content. No effect of elevated CO₂ on plant biomass was observed in any of the diversity treatments except in the first year following planting. We suggest that changes in species

richness of these calcareous grassland communities will have a strong influence on ecosystem functions even at levels of species richness greater than five.

Marcel G. A. van der Heijden, Ruth Streitwolf-Engel, Ian R. Sanders, Thomas Boller & Andres Wiemken (Botanisches Institut, Universität Basel, Hebelstr. 1, CH-4056, Schweiz): Diversity of arbuscular mycorrhizal fungi as a potential determinant of plant community diversity.

Arbuscular mycorrhizal fungi (AMF) form mutualistic symbioses with the roots of approx. 80% of plant species. In species-rich grasslands, highly diverse communities consisting of many different AMF species occur. The function and importance of these diverse AMF communities for plant communities is, at present, unknown. If the growth of plant species is differentially affected by different AMF species then the diversity and species composition of AMF communities could be important in determining plant community diversity. To test if plant species respond differently to different AMF species, three plant species were inoculated with four different AMF species, all of which originated from the same species-rich grassland. The plant species responded differently to each of the AMF species. Furthermore, by using multivariate statistical techniques we show that the degree to which the plants responded to each of the AMF isolates varied among the plant species. Some plant species responded differently to almost every AMF species tested while other plant species respond indifferently to several AMF species even though they benefit from the symbiosis. The results suggest firstly that the fitness of some plant species may be much more dependent on which AMF species colonises their roots than in other plant species and secondly that plant species coexistence may depend on which AMF species colonises plant roots. AMF diversity may, therefore, strongly influence plant community structure by differentially affecting plant species.

Stephan Ledergerber, Claudine Dolt & Bruno Baur (Institut für Natur-Landschafts- und Umweltschutz (NLU), Universität Basel, St. Johannis-Vorstadt 10, CH-4056 Basel, Schweiz): Assessment of grazing pressure in a fragmented grassland.

Habitat fragmentation is expected to change the abundance of species, species composition and interactions between species (e.g. plant-herbivore interactions) in the remnants. We examined grazing damage in the three plants *Betonica officinalis*, *Cirsium vulgare* and *Salvia pratensis* in experimentally fragmented grasslands in the Swiss Jura mountains. The extent of grazing damage increased in all three plants from July to September 1996. The grazing damage varied among species and reached a maximum of 18% of leaf area consumed in *S. pratensis*. Grazing pressure was assessed in fragments and corresponding control plots by exposing seedlings of *Trifolium repens*, grown in little dishes, to herbivores (grasshoppers and gastropods) in the field. Herbivore pressure was lower in experimentally fragmented plots than in the control plots. Furthermore, herbivore pressure decreased with fragment size. These effects were significant in June but not in September 1996. This could be explained by differences in plant growth and changes in herbivore density between fragmented and non-fragmented areas, as well as by seasonal changes in the composition and activity of herbivores.

Hans-Peter Rusterholz & Andreas Erhardt (Botanisches Institut der Universität Basel, Schönbeinstrasse 6, CH-4056 Basel, Schweiz): Do butterflies select for specific nectar constituents? From field observations to experiments.

For most butterflies, nectar is the most important food resource in their adult stage. Since butterfly-pollinated flowers have high sucrose:hexose ratios and high levels of amino acids in their nectar, the question arises if butterflies select for these specific nectar properties. Field observations in the Swiss Jura mountains showed that males and females of *Lysandra bellargus* differ in their flower preferences. These differences are correlated with differences in

nectar characteristics of the preferred flowers: males preferred flowers with high amounts of sucrose in their nectar whereas females tended to prefer flowers with nectar rich in amino acids. Nectar preference experiments with *Inachis io* butterflies showed that (1) males and females preferred both sucrose and fructose over glucose and also sucrose over fructose. (2) In tests with mixed sugar solutions, the butterflies clearly preferred both sucrose-dominant and balanced sugar solutions over hexose-dominant sugar solutions. (3) Females clearly preferred a mimic of *Lantana camara* nectar containing amino acids over a corresponding plain sugar solution, whereas males did not discriminate between these test solutions. These results confirm the hypothesis that butterflies select for high levels of sucrose and amino acids in floral nectar, and suggest that adult feeding may also play an important, if so far not adequately recognised role for longevity and reproduction in butterflies.

Posters

Adrian Aebischer (Zoologisches Institut, Universität Freiburg, Péroilles, CH-1700 Freiburg, Schweiz): Determinants of bird abundance changes in a periodically disturbed environment.

Monique Derron (Sekretärin der SKEW, Domaine de Changins, case postale 254, CH-1260 Nyon 1): Schweizerische Kommission für die Erhaltung von Wildpflanzen - SKEW / Commission suisse pour la conservation des plantes sauvages - CPS / Commissione svizzera per la conservazione delle piante selvatiche - CPS.

Das Ziel der SKEW ist die Forderung des Schutzes der genetischen Vielfalt der wildwachsenden Pflanzen. Die SKEW unterhält ein Sekretariat, das als Informations- und Vermittlungsstelle funktioniert und in kooperativer Verbindung mit dem BUWAL, dem SBN, den Kantonalen Naturschutzfachstellen sowie den Botanischen Gärten und Universitätsinstituten steht. Es unterstützt und initiiert auch selber Projekte. Im Bereich der Arterhaltung wurde die Priorität auf die europaweit gefährdeten und seltenen Arten in der Schweiz gelegt. Aufgrund der vom Sekretariat auf Umfragen basierenden aufgebauten Datenbank, Literatur- und Herbarrecherchen sowie umfassender Feldarbeit wurden 1995 und 1996 von Ch. Käsermann die Bestandesentwicklung sowie die Gefährdung von 36 Arten untersucht und aufgrund der Resultate aktuelle Verbreitungskarten sowie Vorschläge für geeignete Schutzmassnahmen aufgestellt. Die Ergebnisse werden für jede bearbeitete Art in einem Merkblatt zusammengefasst und an die zuständigen Stellen zur Information verschickt. Im Bereich der Erhaltung der genetischen Vielfalt innerhalb der Arten hat die SKEW "Empfehlungen zur Gewinnung und Verwendung von standortgerechtem Saat- und Pflanzgut" mit allgemeinen Richtlinien und Artenlisten erarbeitet.

Monique Derron¹ (Sekretärin - SKEW), **Raoul Palese**² (Koordinator - CRSF), **Beat Bäumler**² (Mitarbeiter - CRSF) & **Daniel Moser**² (Mitarbeiter - CRSF) (¹Sekretariat SKEW, Domaine de Changins, case postale 254, CH-1260 Nyon 1; ²CRSF, case postale 60, CH-1292 Chambésy (Genève) / ZDSF, Altenbergrain 21, CH-3013 Bern, Schweiz): Erhaltung der gefährdeten Arten in der Schweiz, 1. Teilprojekt. Zusammenarbeit ZDSF - SKEW (Zentrum des Datenverbundnetzes der Schweizer Flora, Schweizerische Kommission für die Erhaltung von Wildpflanzen).

Die 1995/96 erstellte Datenbank zu 36 europaweit gefährdeten und seltenen Arten der SKEW und die weiteren beim SKEW-Sekretariat eingegangenen und eingehenden Fundmeldungen werden an das ZDSF übergeben. 1997 wird ein erstes gemeinsames Projekt "Erhaltung der gefährdeten Arten in der Schweiz, 1. Teilprojekt" durchgeführt. Die so erhal-

tenen Daten werden vom ZDSF aufgearbeitet, das unter anderem aktuelle Verbreitungskarten aufstellt. Die SKEW gibt Merkblätter zu den neu bearbeiteten Arten heraus und leitet weitere Projekte zu den am stärksten gefährdeten Arten ein. In Zukunft werden die Informationen laufend zwischen beiden Institutionen ausgetauscht das Ziel ist folgendes: das ZDSF verarbeitet die Grundlageninformationen und liefert Karten mit dem ehemaligen und dem aktuellen Verbreitungsgebiet; die SKEW kann aufgrund dieser Angaben zusammen mit ihren eigenen Informationen die Gefährdungssituation einer Art beurteilen und gezielte Artenschutzprojekte initiieren.

Claudine Dolt, Stephan Ledergerber & Bruno Baur (Institut für Natur-, Landschafts- und Umweltschutz (NLU), Universität Basel, St. Johannis-Vorstadt 10, CH-4056 Basel, Schweiz): A quantitative analysis of standing crop in artificially fragmented grasslands.

Habitat fragmentation may affect plant growth at the edges of fragments. We examined this hypothesis by measuring the aboveground plant biomass production in artificially fragmented, unfertilised calcareous grasslands in the Swiss Jura mountains. The aboveground plant biomass was collected in 48 fragments (12 fragments measuring 4.5 x 4.5 m, 12 fragments 1.5 x 1.5 m and 24 fragments 0.5 x 0.5 m and 48 control plots of corresponding size) in October 1996. In small and medium-sized fragments the plant biomass (expressed as g DW/m²) was significantly larger than in control plots of the same size. In fragments plant biomass per area decreased with fragment size, whereas in control plots no size effect was found. The increase of plant biomass per area in the fragments may mainly be due to edge effects. The increased plant biomass may change interactions among plants as well as interactions between plants and herbivores.

Peter M. Frischknecht¹, Regula Steiner² & Olaf Weber² (¹Departement für Umweltnaturwissenschaften, ETH Zürich; ²Umweltnatur- und Umweltsozialwissenschaften, ETH Zürich, Schweiz): Bewertung von Biodiversität durch Interessensgruppen als Grundlage für Raumnutzungsverhandlungen.

Ein zentrales Problem für die Erhaltung von Biodiversität ist die Verfügbarkeit des notwendigen Raums. In der Regel bestehen für jede Fläche verschiedenartige Nutzungsinteressen, die miteinander in Einklang gebracht werden müssen.

Im Rahmen einer Fallstudie zum Zentrum Zürich Nord wurde für die Grünraumplanung ein empirisches Verfahren angewendet, das auf einer Bewertung des Grünraums durch Vertreter und Vertreterinnen von Interessensgruppen basiert. Es wurde ein sogenannter Explorationsparcours aufgebaut, der aus einer Folge von Interviews und Situationsbegegnungen bestand und eine Beschreibung der Interessen von Akteurgruppen ermöglichte. Im Zentrum dieses Explorationsparcours stand eine computergestützte Bewertung zentraler Kriterien der Grünraumgestaltung. Diese Kriterien umfassten die ökologische, umwelthygienische, soziale und ökonomische Perspektiven.

Es zeigt sich, dass auf einer emotionalen Ebene die ökologische Perspektive sehr hoch bewertet wird, bei einer multikriteriellen Bewertung, basierend auf entscheidungstheoretischen Grundlagen, jedoch andere Perspektiven stärker gewichtet werden. Zudem können auch unterschiedliche Interessen der einbezogenen Gruppen nachgewiesen werden.

Auf der Basis dieser offengelegten Interessenlage könnten in einem nachfolgenden moderierten Verhandlungsprozess Nutzungskonflikte entschärft und gleichlaufende Interessen für eine multifunktionelle Nutzung des Raumes ausgenützt werden.

Nadine Gerber & Andreas Stampfli (Geobotanisches Institut, Universität Bern, Schweiz): Vegetations-Monitoring in artenreichen Wiesen.

Globale Umweltveränderungen und ein rascher tiefgreifender Wandel in der Landwirtschaft erschweren die Aufgabe, die biologische Vielfalt von Lebensgemeinschaften durch

geeignete Nutzung langfristig zu erhalten. Rechtliche Grundlagen zur Erhaltung artenreicher Wiesen sind in der Schweiz vorhanden, es besteht jedoch ein grosser Handlungsbedarf zugunsten der Artenvielfalt. Am Beispiel der Tessiner Magerwiesen werden Schwachpunkte staatlicher Naturschutzbemühungen aufgezeigt. Die gegenwärtigen Massnahmen und Instrumente sind ungenügend, weil sie dem starken Rückgang von Wiesenarten in einzelnen Regionen nicht zielgerichtet entgegenwirken. Wir schlagen als Ergänzung vor, dass in den heute weitgehend bekannten "regionalen Zentren des Artenreichtums" bestimmte Flächen kontrolliert genutzt werden und einer langfristigen Überwachung der Artenvielfalt erste Priorität eingeräumt wird. Beispiele des Vegetations-Monitorings in solchen "Schwerpunktgebieten" werden vorgestellt.

Rob Hendriks & Joop Ouborg (Department of Ecology, University of Nijmegen, The Netherlands): Genetic erosion and loss of biodiversity. The current use of population genetic theory in nature conservation in the Netherlands.

In this one year pilot project, funded by the Dutch Prins Bernhard Fund, the (potential) role of population genetic theory in nature conservation is the subject of study. A provisional literature survey provided the theoretical aspects that are most relevant to the conservation of populations and species in an increasingly fragmented Dutch landscape. Based on these insights an inventory is being made of the practice of nature conservation and the policy towards genetic erosion, reintroduction of species, the use of corridors, etc. among the main nature conservation organisations in the Netherlands. Furthermore current and planned Dutch research activities in the area of conservation genetics are being listed in order to determine to what extent policy, practice and research are in line with each other and with the main questions resulting from the literature survey.

Fridli Marti¹ & André Stapfer² (¹quadra – Beratungsgemeinschaft für Naturschutz und Landwirtschaft, Zürich; ²Baudepartement des Kantons Aargau, Abt. Landschaft und Gewässer, Aarau): Controlling and reporting in nature conservation: assessing the success of conservation measures and monitoring ecological change in the canton of Aargau.

In the canton of Aargau there is currently an extensive programme underway for assessing the success of conservation measures and for monitoring ecological change ("Kontrollprogramm"). This programme has been developed for the years 1993 to 2001 by the cantonal agency for nature conservation as part of the programme "Nature 2001". It is based on some ten years of experience with monitoring in the canton of Aargau. During development and application several aspects have been recognised as vital for a successful realisation:

- Proper definition of goals and targets for conservation measures.
- Clear distinction between assessing implementation, effectiveness and target definition.
- Extensive coordination between projects for conservation measures and projects for assessing their success.
- Presentation of the results of monitoring and assessing the success by means of environmental reporting and performance review (feedback for environmental policy and public opinion).

Some of the projects that have been developed according to these guidelines are: assessing the success of management measures in nature reserves and of financial subsidies in agriculture as well as monitoring of biodiversity in managed landscapes and in biodiversity hotspots. After only the first few years the usefulness of the programme became evident: Some of the projects have already revealed first trends which in some cases allowed an optimisation of different conservation measures and processes.

Raoul Palese (Koordinator), **Beat Bäumler** (Mitarbeiter) & **Daniel Moser** (Mitarbeiter) (CRSF, case postale 60, CH-1292 Chambésy (Genève) / ZDSF, Altenbergrain 21, CH-3013 Bern, Schweiz): Zentrum des Datenverbundnetzes der Schweizer Flora - ZDSF / Centre du Réseau Suisse de Floristique - CRSF / Centro della Rete Svizzera di Floristica - CRSF.

Die grundsätzlichen Aufgaben des Zentrums sind der Aufbau, der Unterhalt und die Weiterentwicklung einer gesamtschweizerischen floristischen Datenbank, welche vielfältige Angaben zur Flora der Schweiz sammelt. Es trägt mit diesen Daten zu einer kontinuierlichen Überwachung der pflanzlichen Biodiversität der Schweiz und zum Schutz von Biotopen und Arten bei, indem es für Naturwissenschaftler und Verantwortliche in Natur- und Landschaftsschutz für Auskünfte zur Verfügung steht. Die Datenbank erlaubt nicht nur die Verwaltung, sondern auch die Auswertung der Daten auf vielfältige Weise, wie z. B. das Erstellen aktueller Verbreitungskarten, die Aktualisierung Roter Listen oder die Herausgabe der Fortschritte in der Schweizer Floristik. Mit dem in der Datenbank enthaltenen Synonymie-Index der Schweizer Flora und der angrenzenden Gebiete hat das ZDSF zudem eine wichtige Grundlage für die Vereinheitlichung der Nomenklatur der Schweizer Flora geschaffen.

Die Stiftung des ZDSF vergütet über zwei Geschäftsstellen in Genf (Conservatoire et jardin botaniques) und in Bern (Geobotanisches Institut) deren Arbeit von zahlreichen ehrenamtlichen Mitarbeitern unterstützt wird.

Finanziell getragen wird das ZDSF zurzeit durch die Gründungsmitglieder (SANW, SBN, SBG, Stadt Genf) sowie durch Beiträge des BUWAL, der Universität Bern sowie etlicher Kantone.

Andreas Stampfli & Michaela Zeiter (Geobotanisches Institut, Universität Bern, Schweiz): Can plant species decline due to abandonment of meadows be reversed by mowing?

Two experiments were carried out in an abandoned meadow situated in close vicinity to a mown meadow on the slope of Monte Generoso (southern Switzerland). During 20 years of abandonment species richness was strongly reduced due to competitive exclusion by the dominant grass *Brachypodium pinnatum*. In the first experiment annual mowing in July and October during eight years did not affect the proportions among abundant species. The majority of new species were most probably recruited from the persistent seed bank or from vegetative parts in the soil. The second experiment showed that species from an adjacent meadow were able to establish after having been sown in mown and burnt plots in the abandoned meadow. But there was no obvious case of spontaneous long-distance immigration. It is concluded that the former species composition of abandoned meadows cannot easily be restored by mowing because many plant species of meadows do not have persistent seed banks, and successful long-distance immigration is very unlikely.

Regula Tester (Urs Graf-Str. 11, 4052 Basel, Schweiz): A new indirect method for dormouse (Gliridae) recording.

The recent distribution and habitat preferences of dormice, especially in European alpine regions coincide neither with climatic factors nor with habitat availability. It is assumed that the distribution is a consequence of Pleistocene immigration and/or interspecific competition. Using a new method, called "hairtubes", which was described for the Hazel dormouse (*P. Bright* & *P. Morris*, *Mammal Society no. 11* (1989)), it was possible to demonstrate the occurrence of all four central European dormice species in an area about 200 km² in a single field season by one person. There were four localities in which two or three different species occurred in sympatry. The method is very useful to easily get basic information about distribution, habitat preferences and coexistence. The method neither harms the animals nor does it reduce their fitness. The method is as successful as life traps, but more efficient, easier to use and less expensive than life traps.

Thomas Walter (Professur für Natur- und Landschaftsschutz, Departement Wald- und Holzforschung, ETH Zürich, Schweiz). Weitere mitwirkende Institutionen und Personen: **BUWAL** (Bern), **CSCF** (Centre suisse de carto-graphie de la faune) **KARCH** (Koordinationsstelle für Amphibien- und Reptilienschutz der Schweiz, 3005 Bern), **Schweizerische Vogelwarte** (Sempach), **Bürogemeinschaft für angewandte Ökologie** /Zürich), **Insecta** (Neuenburg), **Dr. Rainer Neumeyer** (Zürich), **Dr. Achim Otto Erlenbach** (Informatikdienst, ETH Zürich): Aua: Faunistische Datenbank als Instrument für den Naturschutz in der Schweiz unter besonderer Berücksichtigung des Auenschutzes.

Ziel des Projektes ist die Erstellung eines Instrumentariums, um faunistische Aspekte beim Vollzug des Auenschutzes besser berücksichtigen zu können. Dazu wurde als Grundlage eine Datenbank eingerichtet, welche es ermöglicht, folgende Informationen über Tierarten in ihren verschiedenen Entwicklungsstadien miteinander zu verbinden: Biotoptypen, Strukturen, Phänologie, Verbreitung, allgemeine Arteigenschaften, Nahrung, Gefährdung, Systematik, Literatur und Beobachtungen. Die Beobachtungen wurden aus den Datenbanken des CSCF, der KARCH und der Schweizerischen Vogelwarte übernommen. Die weiteren Informationen entstammen der Literatur.

Die Datenbank ist bezüglich der Struktur und den Relationsmöglichkeiten in der vorliegenden Form ein Novum. Von spezieller Bedeutung ist die gesonderte Behandlung verschiedener Entwicklungsstadien der Tierarten bezüglich der ökologischen Eigenschaften. Damit können potentielle Auswirkungen von Bewirtschaftungen und Eingriffen (auch ausserhalb von Auen) auf einzelne Arten oder Artgruppen beschrieben werden. Potentiell in einem Gebiet vorkommende Arten können nach horizontaler und vertikaler Verbreitung und nach Biotoptypen abgerufen und mit den bis anhin in diesen Gebieten registrierten Arten verglichen werden. Ebenso sind z. B. die Gefährdungen und Schutzstatus der Arten in verschiedenen Biotoptypen abrufbar. Sie können als Grundlage für die Festlegung von Schutzprioritäten verwendet werden. Über Eigenschaften einer einzelnen Art kann zudem rasch ein Überblick gewonnen werden. Ergänzungen und neue Erkenntnisse können laufend in die Datenbank integriert werden.

Jürg Zettel, Ursula Zettel & Andreas Ryser (Zoologisches Institut, Universität Bern, Schweiz): Surface activity in *Ceratophysella sigillata* (Collembola: Hypogastruridae) and the influence of climatic parameters.

C. sigillata is a monovoltine species living in lowland forests and displaying a unique biology. Main growing season is winter, reproduction takes place in early spring; summer and autumn are spent in a dormancy. Each individual runs through two polymorphisms with a total of four different morphs: a reproductional polymorphism, and a seasonal polymorphism coupled with dormancy. The species is not evenly distributed in its habitat, but occurs in individual-rich colonies comprising up to more than a million individuals. These colonies show a spectacular and synchronised pattern of surface activity during four time windows: two in winter and two in spring and early summer. Only two morphs are involved in this behaviour. Active colonies may move over the forest floor and may climb on trees to feed on algae colonising the bark.

Surface activity is restricted by low humidity and by temperature. In late spring and early summer high temperatures (above 10°C for adults, above 20°C for juveniles) reduce surface activity, a low threshold is never attained. In winter activity can be observed down to -2°C, at lower temperatures the animals retreat into the litter layer. Feeding may occur at subzero temperatures, too. Values between +5 and 0°C are optimal, at lower values the bimodal diel activity pattern is shifted towards a single peak at dusk. With the presence of snow the surface activity can be observed mainly during late afternoon.

Stephan Zoller & Christoph Scheidegger (Institut für Wald, Schnee und Landschaft (WSL), Birmensdorf, Schweiz): Transplantation of isidia and thallus fragments from the endangered lichens *Parmelinopsis minarum* and *Parmotrema crinitum* as a conservation measure.

The two foliose lichen species *Parmelinopsis minarum* and *Parmotrema crinitum* are considered as critically endangered in Switzerland. *Parmelinopsis minarum* is only known from a few small populations. These populations are especially threatened by forestry measures and stochastic perturbations (e.g. wind throw). The risk of extinction would be reduced by increasing the number of subpopulations on different trees or boulders. To achieve this aim we dispersed vegetative diaspores (isidia) artificially, transplanted small thallus fragments and studied survival, growth rate and development.

The transplantations were carried out in the valley of Bergell. Cotton gauze discs (1 cm diameter) were fixed on selected substrata (boulders and *Abies alba*). Isidia were collected with a small brush from intact thalli and transferred onto the discs. Thallus fragments of both species were fixed with glue next to the discs. Discs and fragments were regularly photographed, samples taken to the lab and studied with a scanning electron microscope. In *P. crinitum* cilia tips established fan shaped contact zones with the cotton fibres within two months. Diaspores of *P. minarum* needed four to six months to form anchoring hyphae. Rain and water run-off can wash the isidia down easily before establishing the attachment and therefore loss of diaspores is considerably high (40-90%). Isidia of *P. crinitum* (with cilia) survived better than *P. minarum* (without cilia). Additional pseudo-meristematic growth zones were formed within six months (*P. crinitum*) and ten months (*P. minarum*). In *P. crinitum* these growth zones developed after 16 months into obovate lobes with up to 0.6 mm diameter. Transplanted thallus fragments survived at all sites but up to 50% of the fragments in *P. minarum* became necrotic or were destroyed by herbivores.

The results prove that transplantation of diaspores and small fragments is a useful method for the conservation of endangered lichens. The risk of extinction of the species through stochastic perturbations will be reduced due to a bigger population size. Further observations will show if the diaspores and fragments can grow and develop successfully to reproducing adult thalli.